

ASRM Multi-Port Igniter Flow Field Analysis

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Abstract

The Advanced Solid Rocket Motor (ASRM) program was initiated by NASA in response to the need for a new generation rocket motor capable of providing increased thrust levels over the existing Redesigned Solid Rocket Motor (RSRM) and thus augment the lifting capacity of the space shuttle orbiter. To achieve these higher thrust levels and improve motor reliability, advanced motor design concepts were employed. In the head end of the motor, for instance, the propellant cast has been changed from the conventional annular configuration to a "multi-slot" configuration in order to increase the burn surface area and guarantee rapid motor ignition. In addition, the igniter itself has been redesigned and currently features 12 exhaust ports in order to channel hot igniter combustion gases into the circumferential propellant slots. Due to the close proximity of the igniter ports to the propellant surfaces, new concerns over possible propellant deformation and erosive burning have arisen. The following documents the effort undertaken using computational fluid dynamics to perform a flow field analysis in the top end of the ASRM motor to determine flow field properties necessary to permit a subsequent propellant fin deformation analysis due to pressure loading and an assessment of the extent of erosive burning.

ASRM Multi-Port Igniter Flow Field Analysis

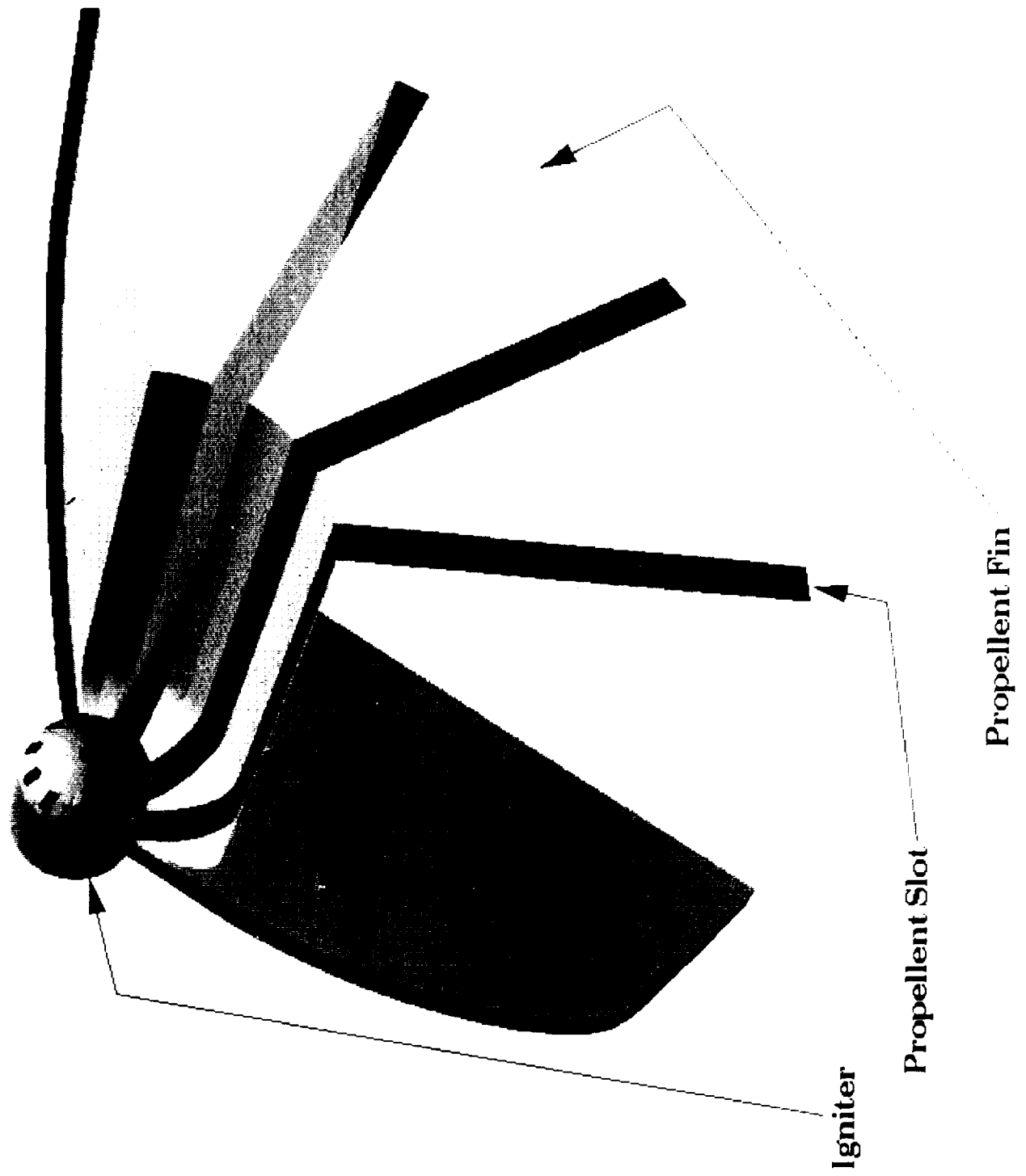
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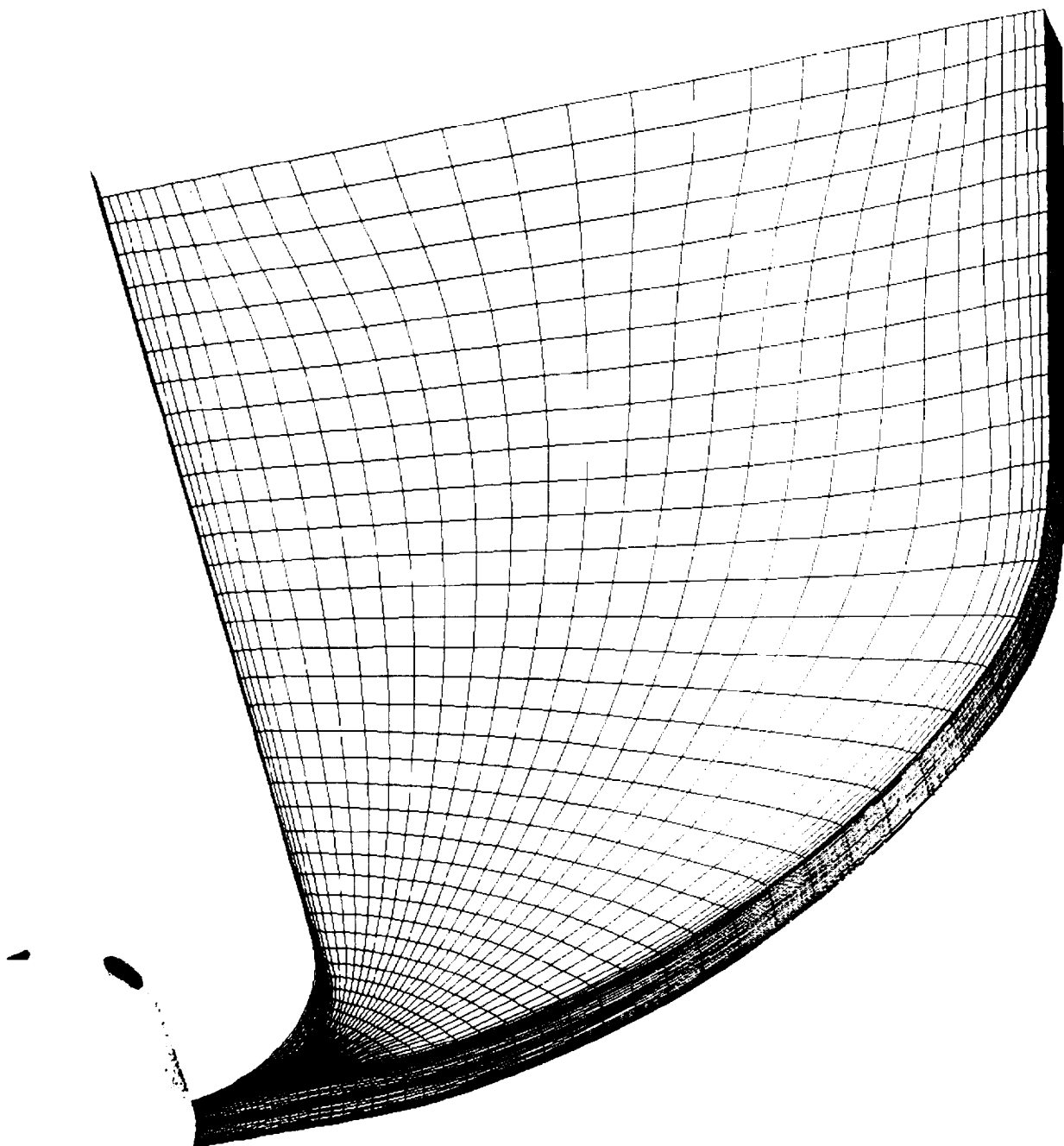


ASRM Head End



- Objective
 - Characterize ASRM Head End Flow Field
- Purpose
 - Estimate propellant surface pressures for deformation analysis
 - Quantify nature of impingement to assess erosive burning
- Approach
 - Three-dimensional CFD analysis
 - * Utilize REFLEQS3D and FDNS
 - * Physical discretization to include region from mid-slot to mid-fin
 - * grid contains 169K points





b. 2. img

- Physical Models
 - Assume steady flow of a perfect gas
 - * $\gamma = 1.166$, $R_{gas} = 1717.03$
 - $K - \epsilon$ turbulence model with wall functions

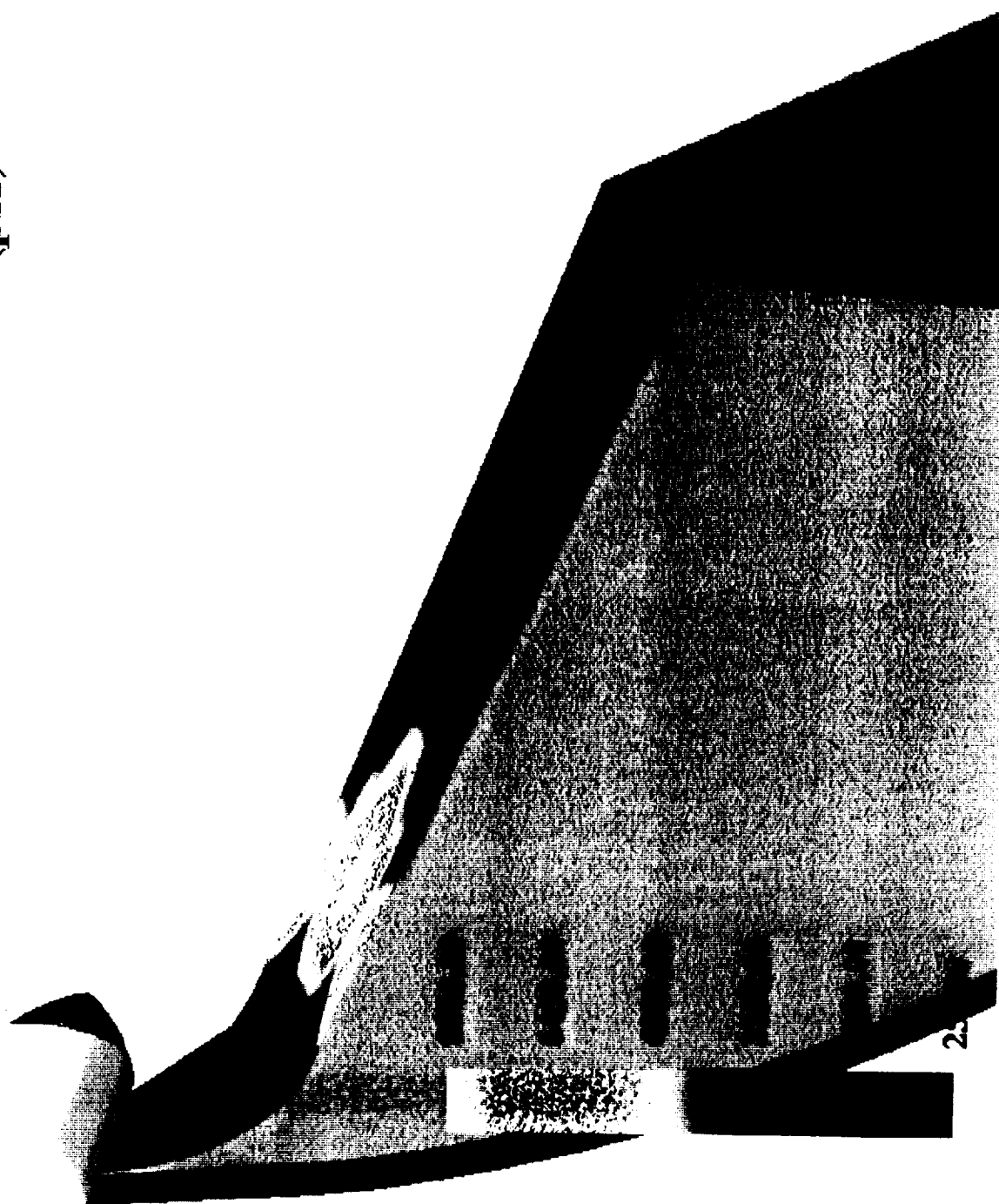


- Igniter Port Flow Conditions

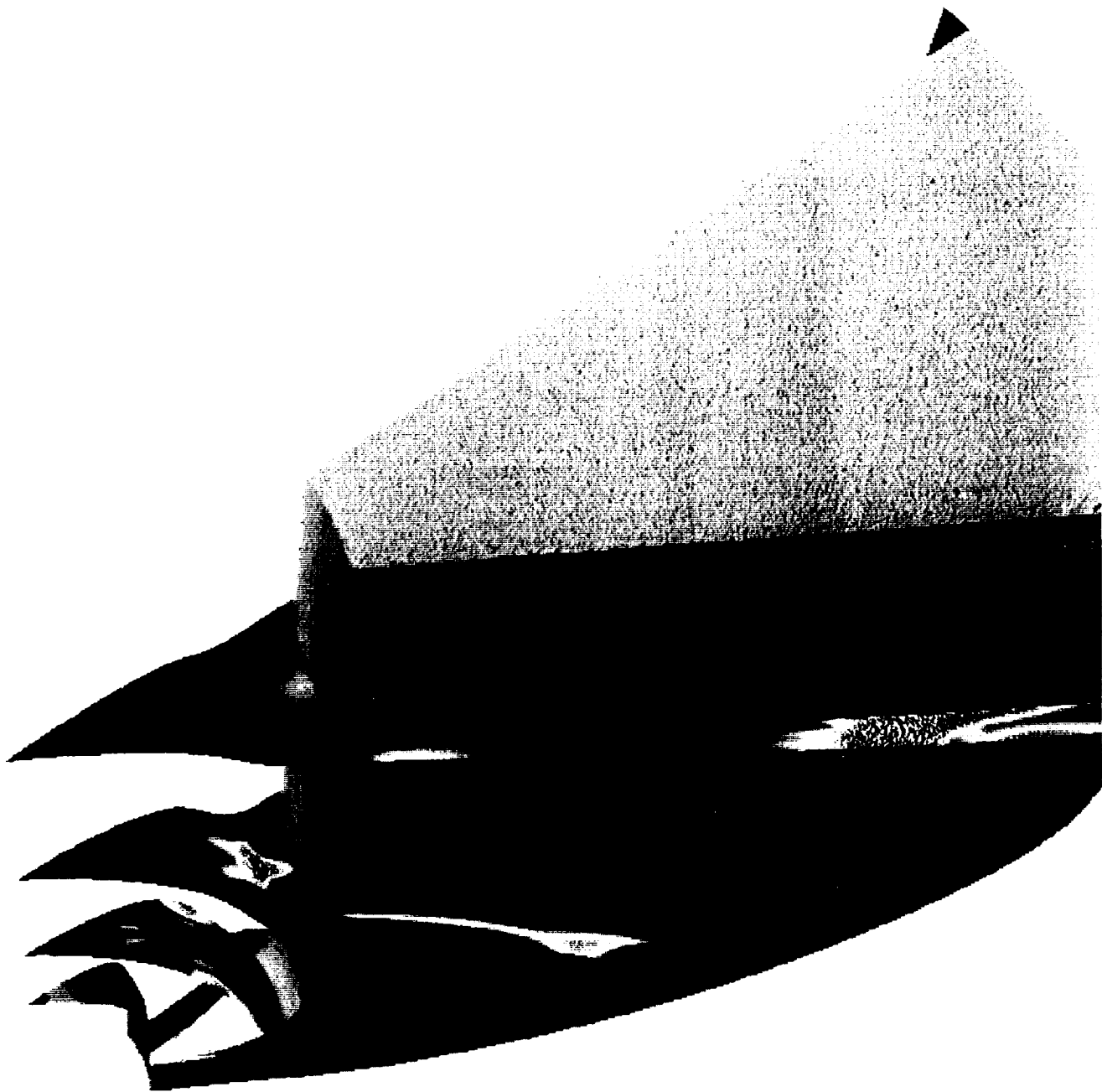
- $P = 145,000 \text{ psf}$
- $T = 5861 \text{ R}$
- $M = 1.0$



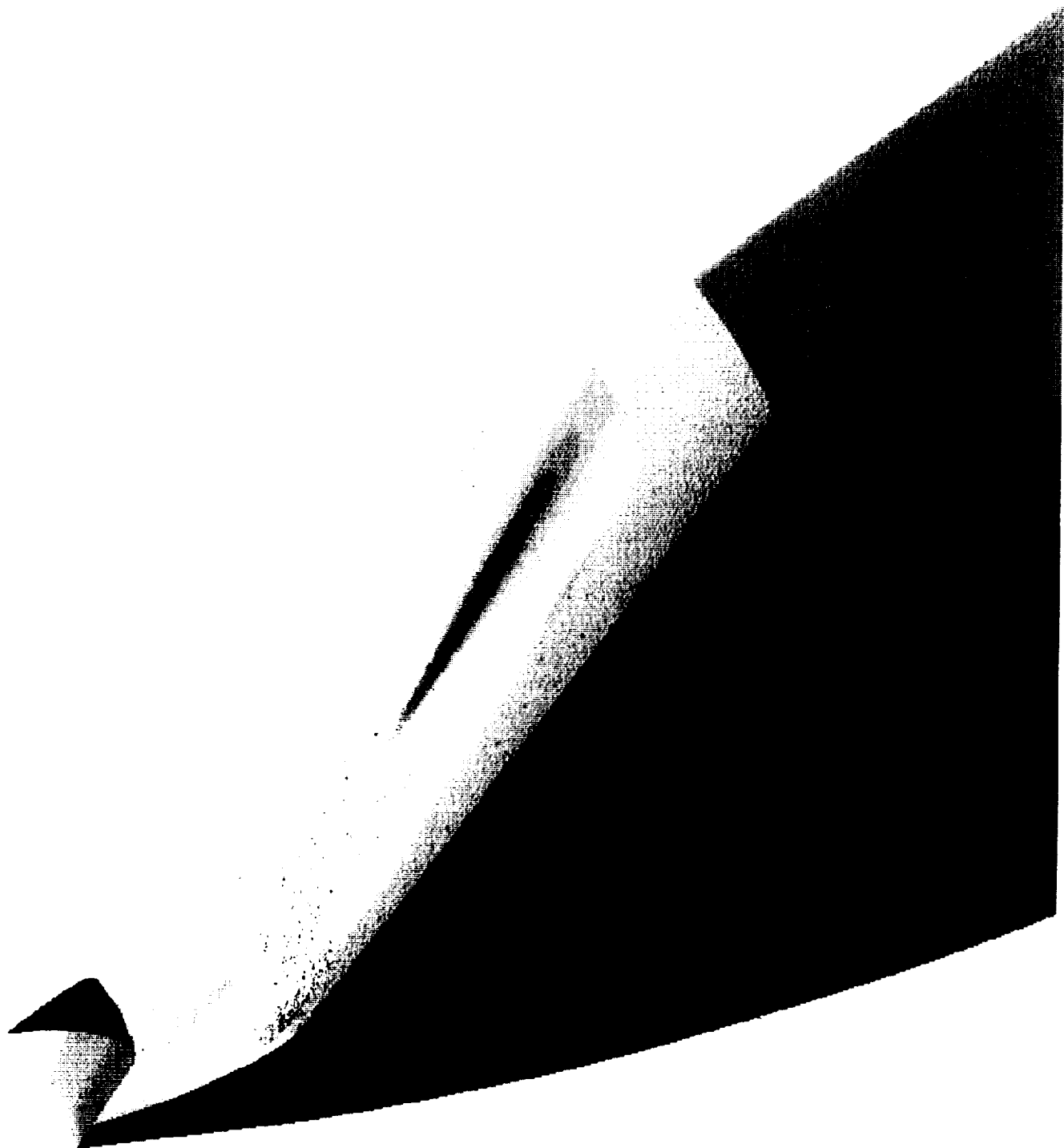
Pressure Contours - Fin Surface (psf)



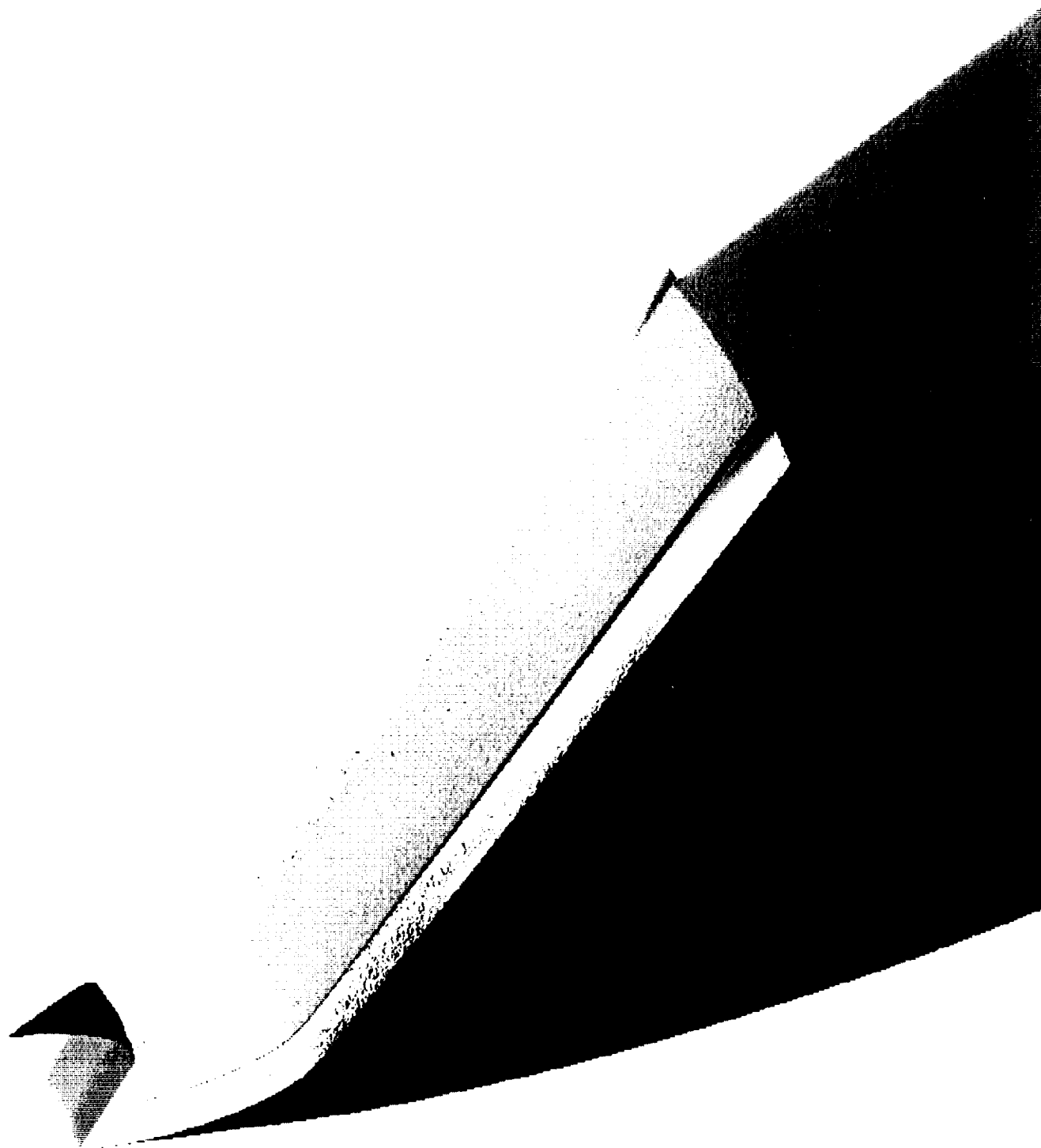
Streamwise Mass Flux Contours



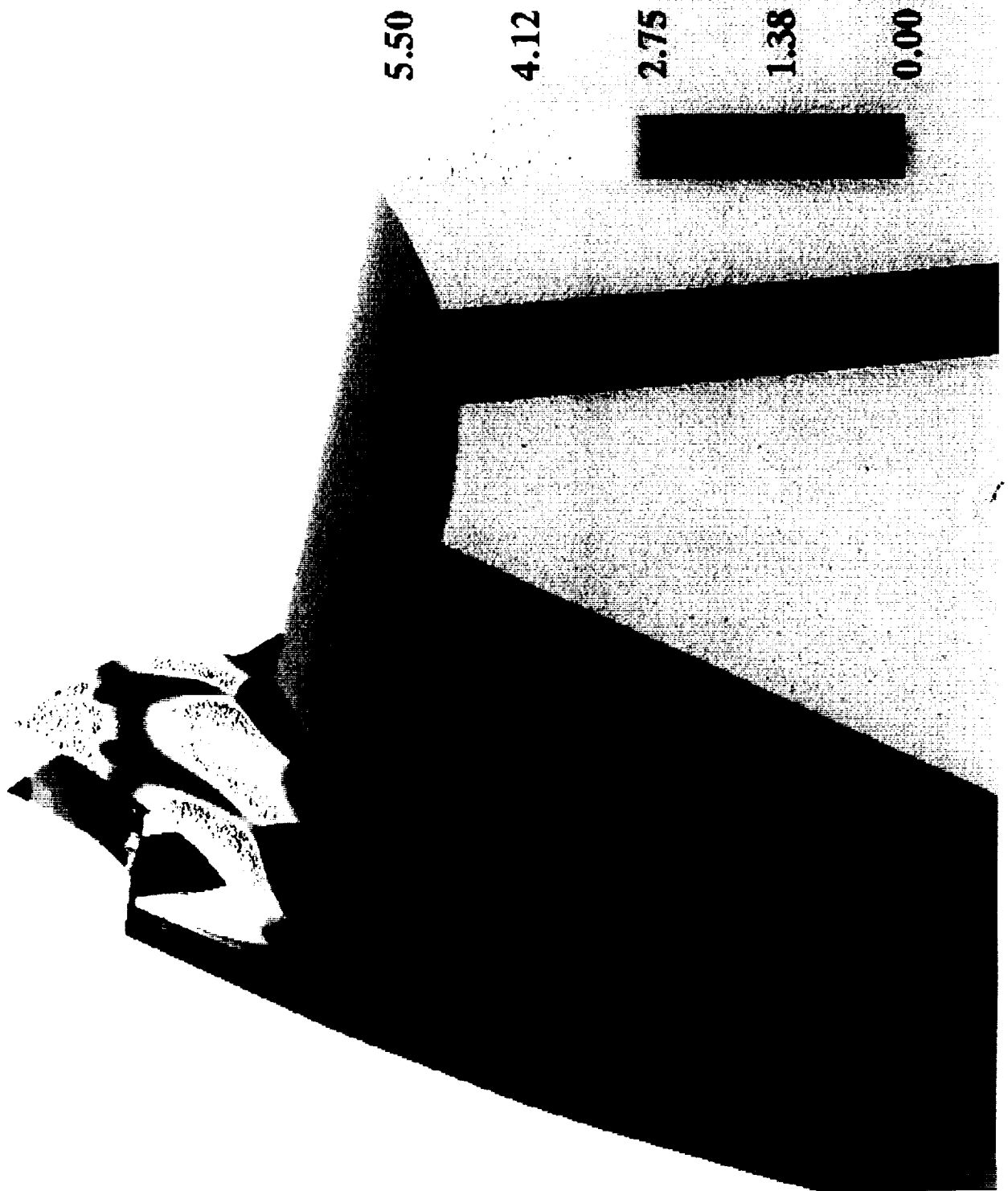
Transverse Mass Flux Contours



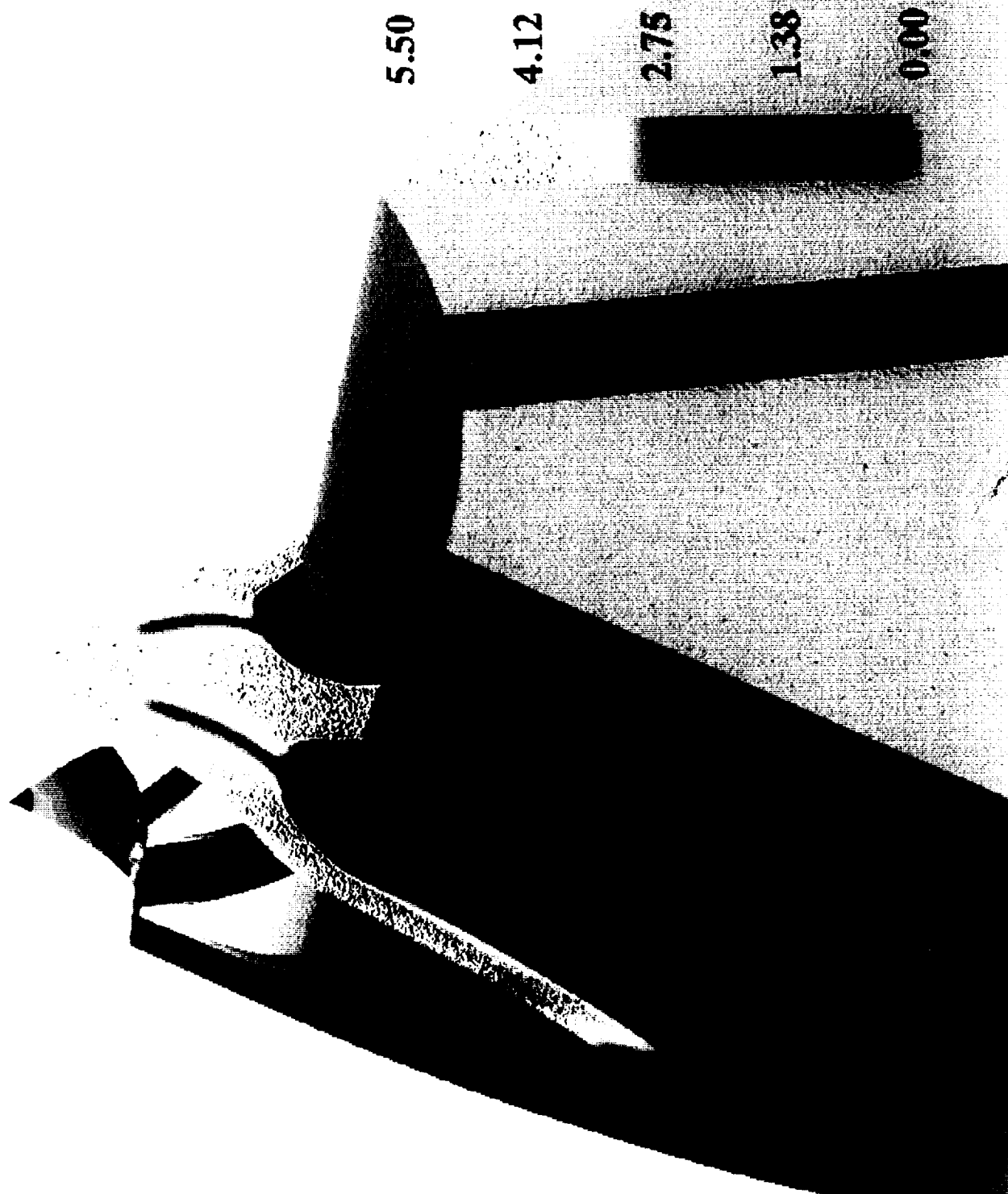
Transverse Mass Flux Contours



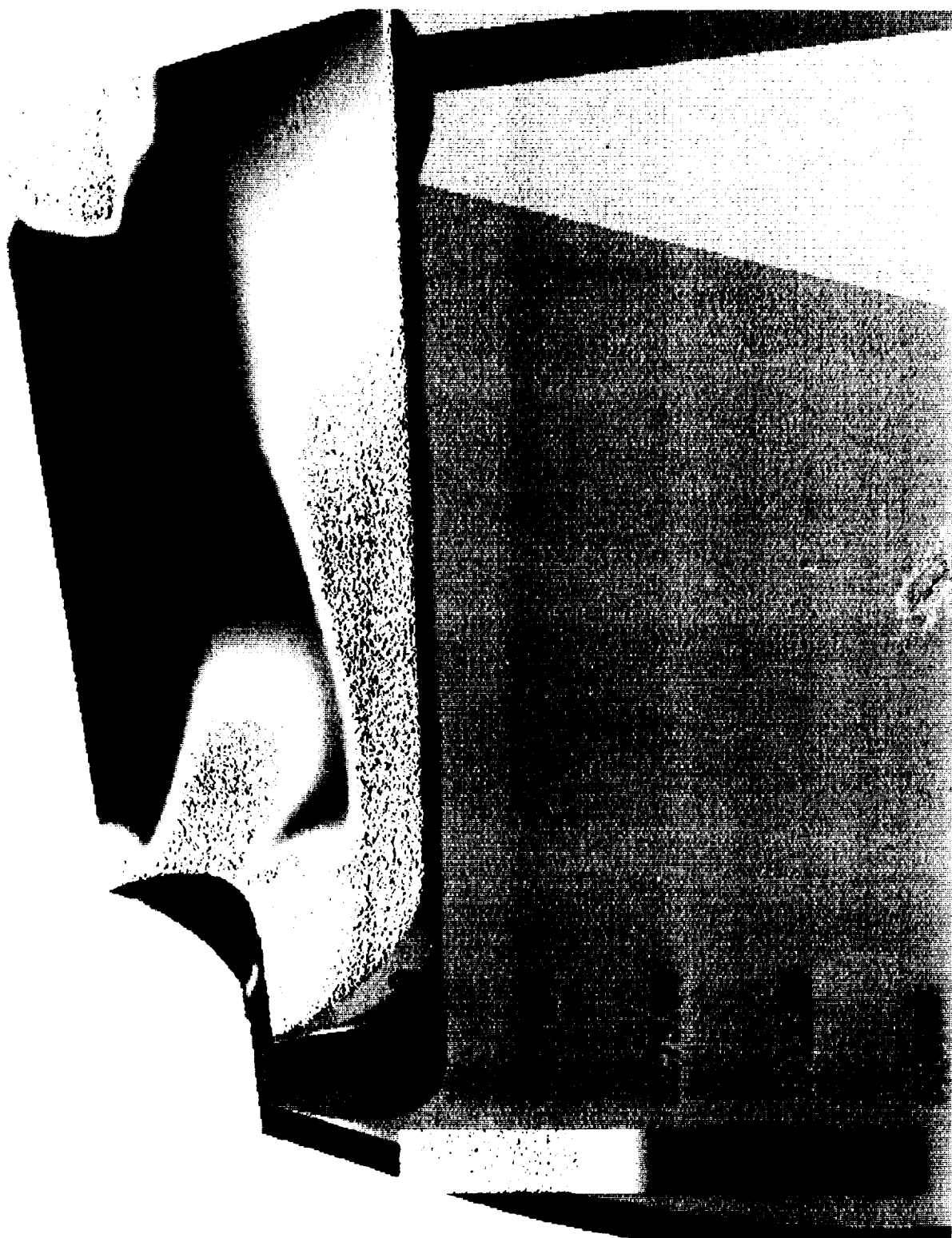
Mach Number Contours



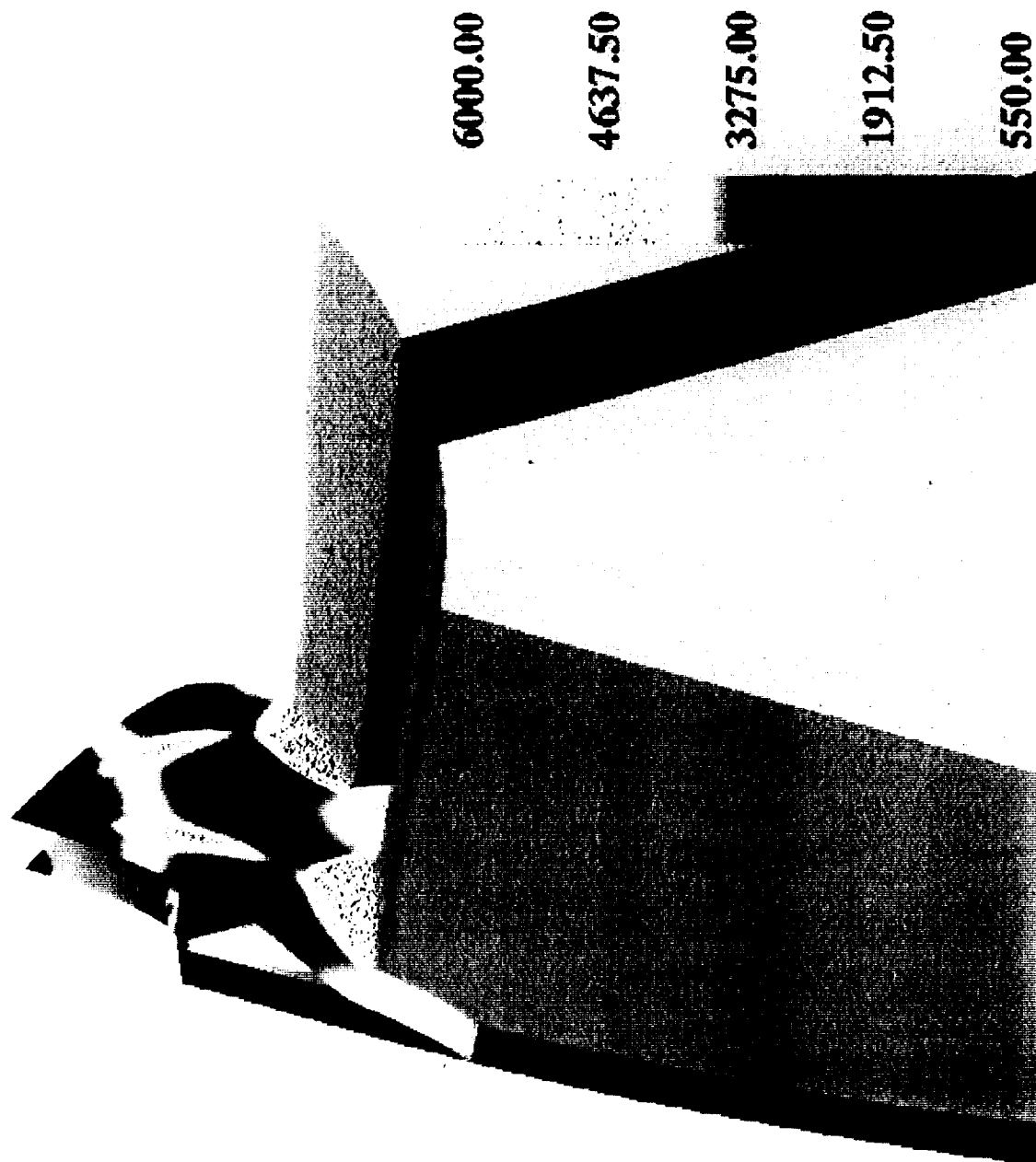
Mach Number Contours



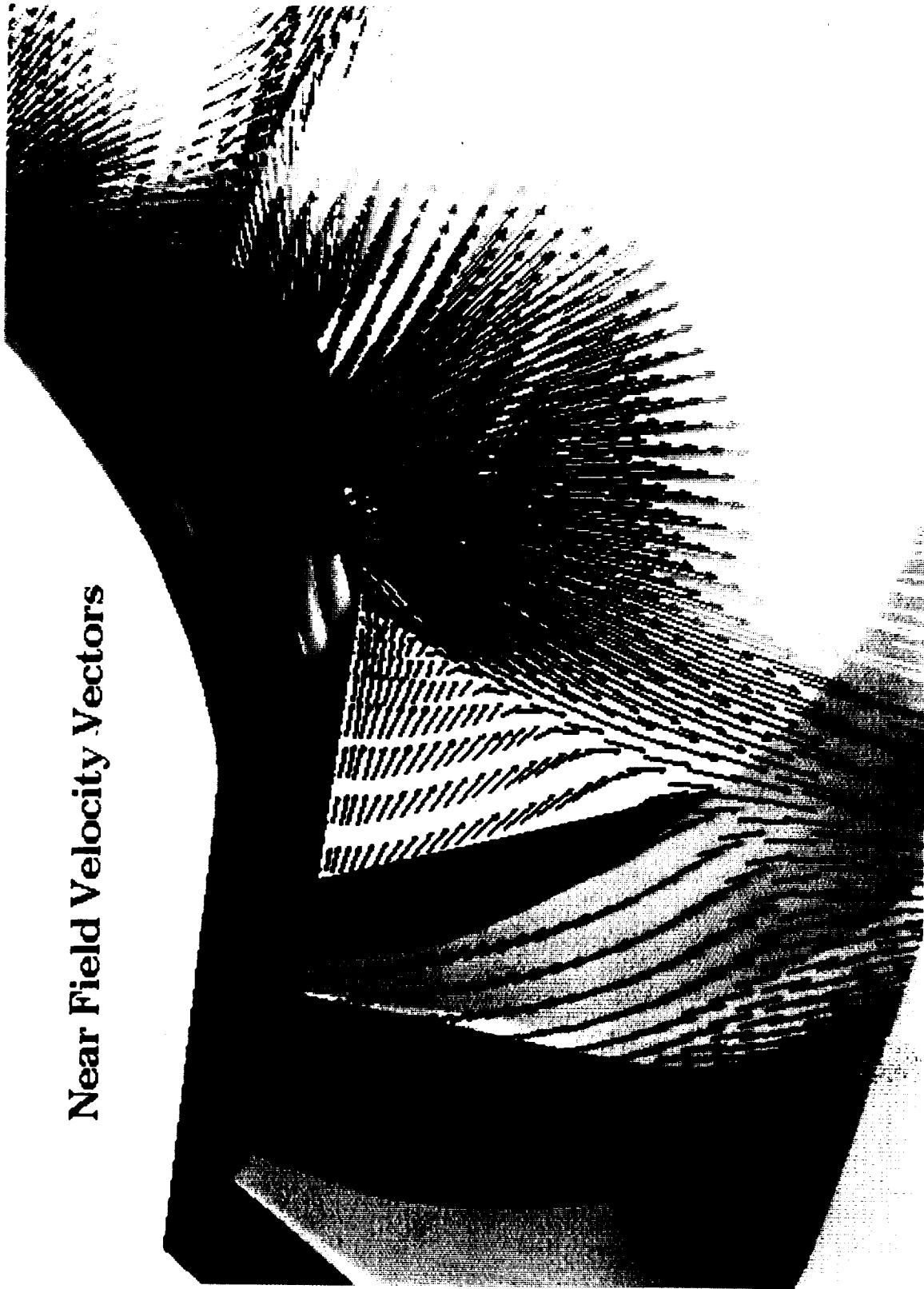
Temperature Contours



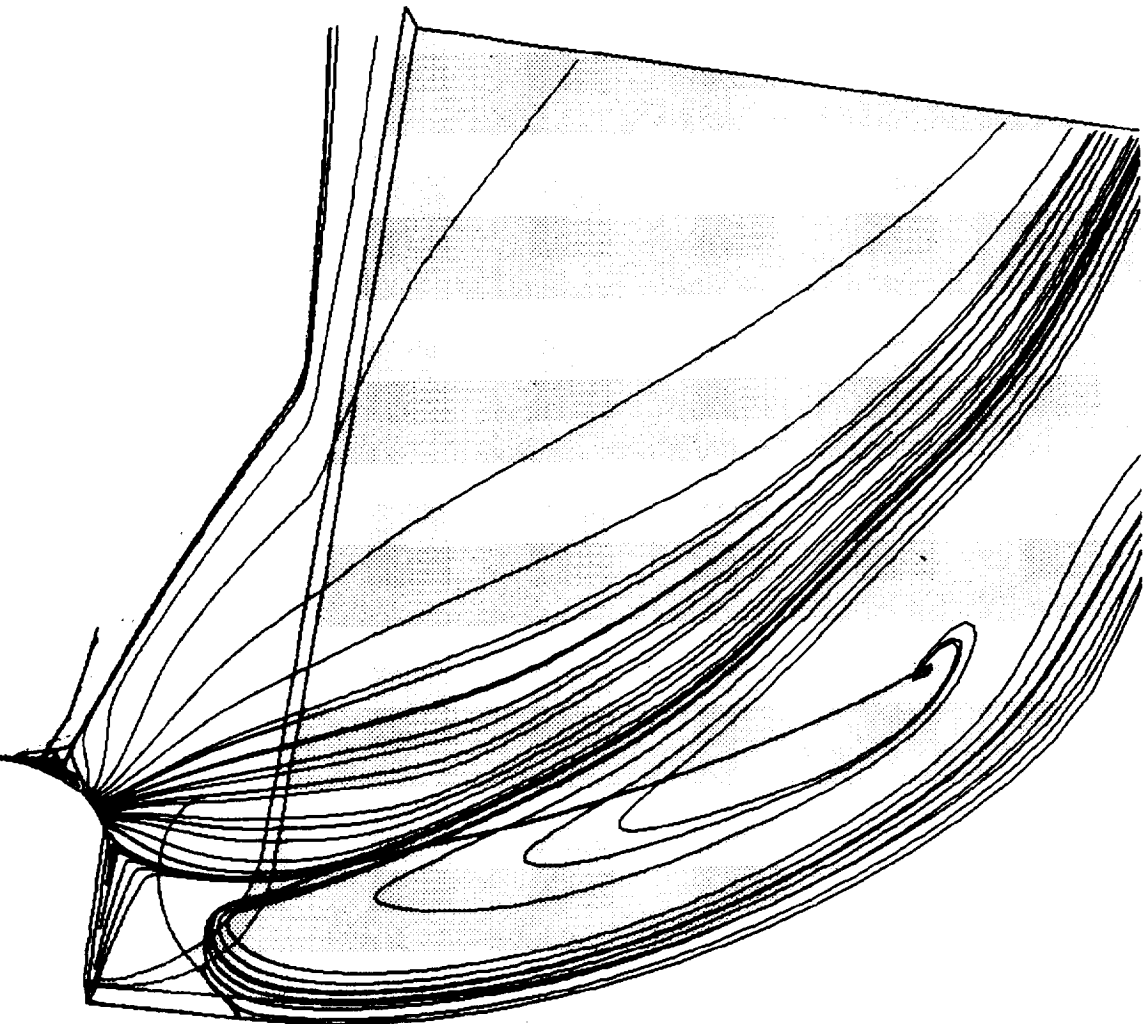
Temperature Contours



Near Field Velocity Vectors

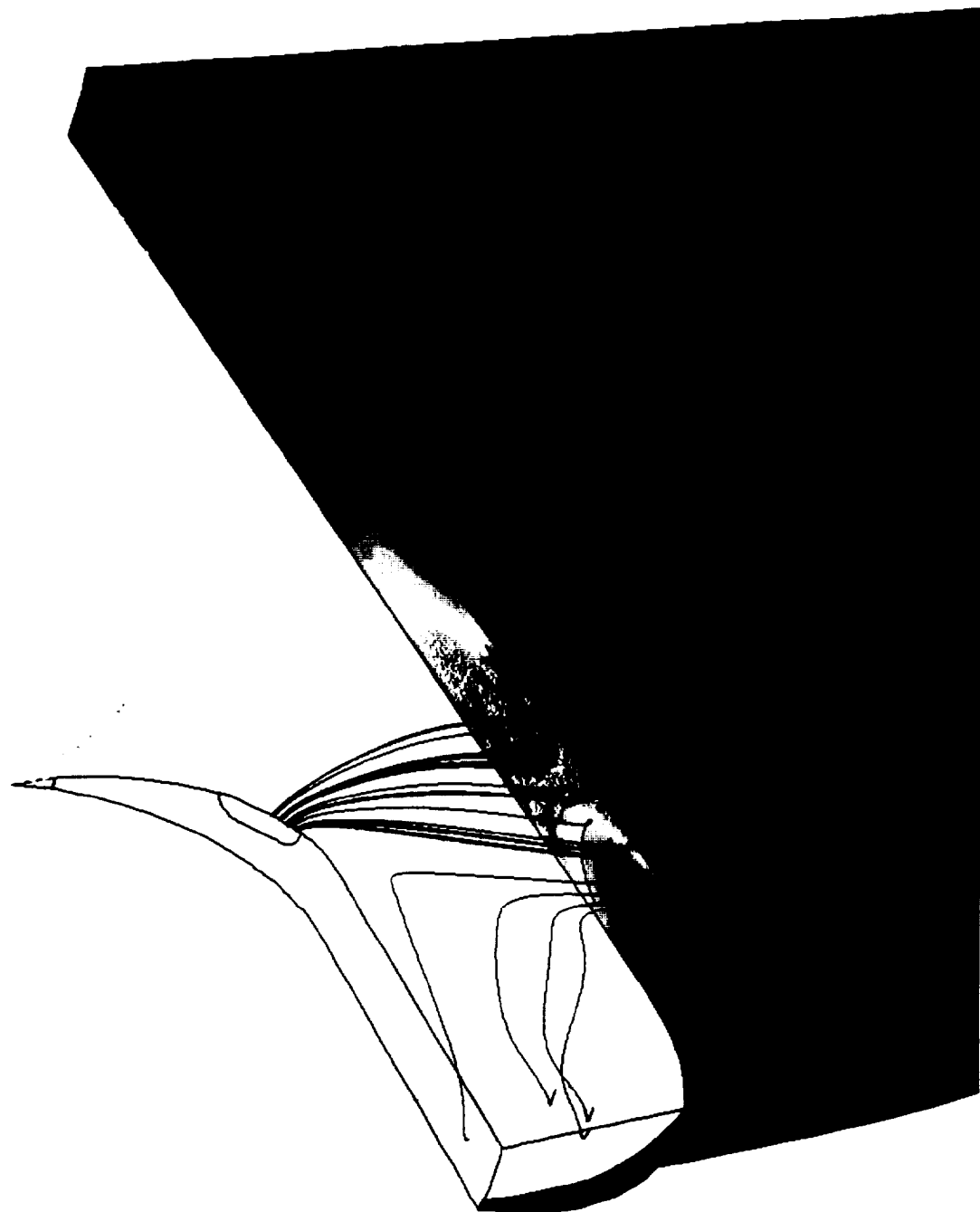


Particle Traces (Center Slot Symmetry Plane)



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Propellant Fin Pressure (psf)



CONTOUR LEVELS
 50.0
 350.0
 650.0
 950.0
 1250.0
 1550.0
 1850.0
 2150.0
 2450.0
 2750.0
 3050.0
 3350.0
 3650.0

p. 2. img

- Conclusions
 - Rapid expansion of port flow plume causes pressure “hot” spots on fin surfaces
 - Subsequent propellant deformation and erosive burning analyses now required



